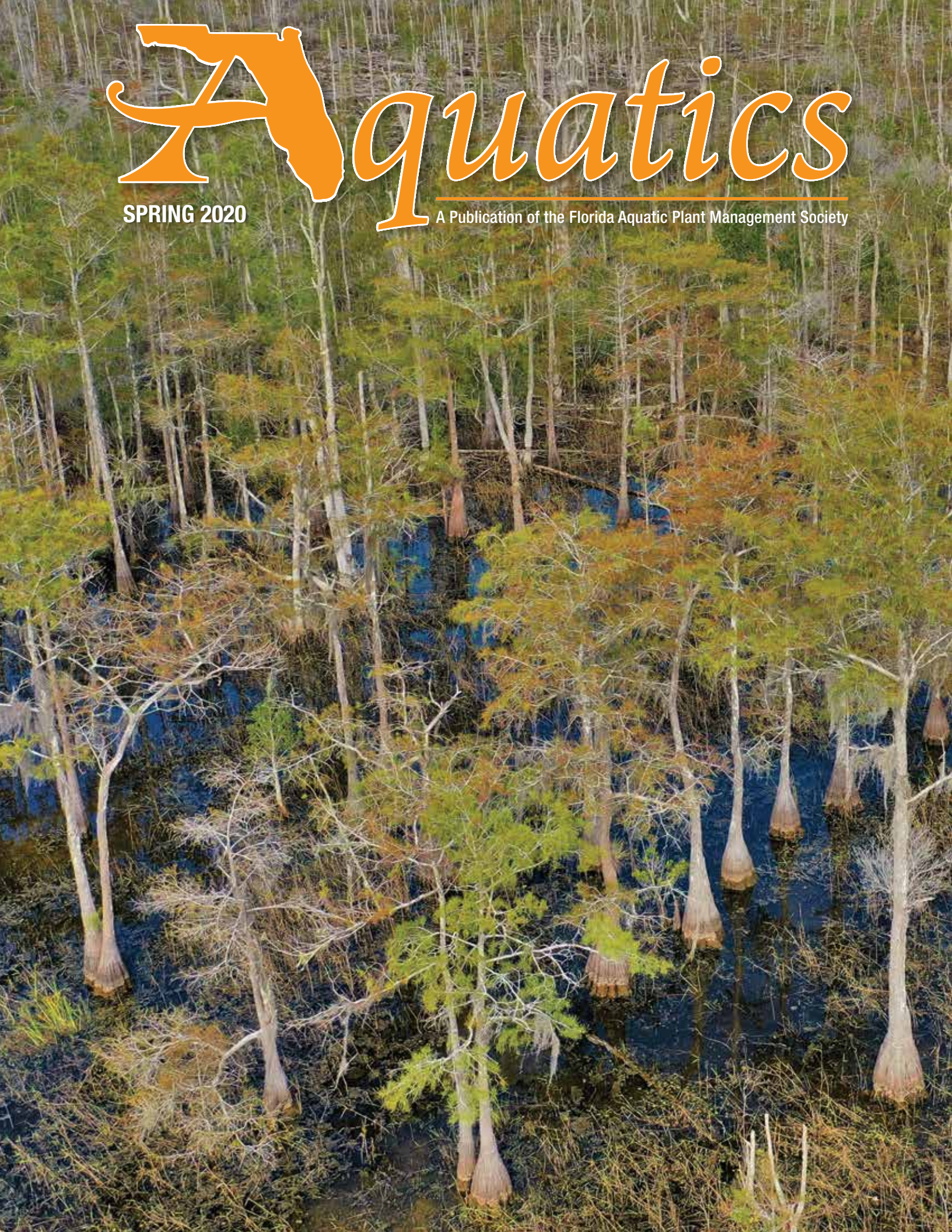

# Aquatics

SPRING 2020

A Publication of the Florida Aquatic Plant Management Society

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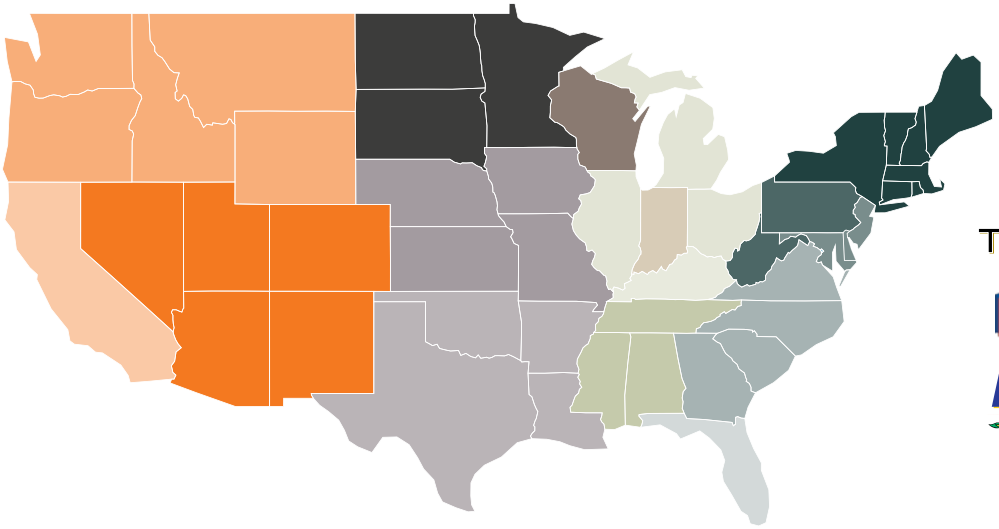

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# Aquatics

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Recent restoration projects in southern Corkscrew Regional Ecosystem Watershed (CREW, East Bonita Springs, FL) are restoring sheet flow across the landscape and eliminating non-native plants. Here, we get a birds-eye view of a young cypress stand thriving amongst the skeletons of countless melaleucas.

*Colin Lewis is a southwest Florida native who enjoys spending every opportunity he gets out in nature. After receiving a Bachelor's Degree in Biology from Florida Gulf Coast University, he worked for the National Audubon Society and the Florida Fish and Wildlife Conservation Commission before accepting a position as an Aquatic Biologist with the Lee County Hyacinth Control District. He is passionate about protecting Florida's native wildlife and ecosystems and sharing their plights through photography. Colin took first and second place in the Vic Ramey Photo Contest/Aquatic Scene categories at the 2019 Annual FAPMS Conference for his imagery. Congratulations, Colin!!*

# Contents



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# A Day at the Beach Spoiled by Invasive Plants

Figure 1: Chandelier Plant, *Kalanchoe delagoensis*. Leaves are simple, sub-cylindric, generally whorled in sets of three, leaves have 3-9 conic teeth at the apex where plantlets develop. Coloration varies from light green with dark green blotching to brown leaf with brownish-purple blotching.

**Dr. Stephen Enloe and Jessica Solomon**
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In the world of aquatic and wetland plant management, people spend countless hours identifying, planning, monitoring, and treating invasive plants. Managers go to great lengths to keep them at bay, preventing population explosions and

the subsequent troubles that come when they get out of hand. Invasive plants can be found in some pretty interesting areas and one potentially unexpected place is at the beach.

Unfortunately, Florida's coastal dune communities are not exempt from invasive plant troubles. Species such as Beach vitex (*Vitex rotundifolia*), Latherleaf (*Colubrina asiatica*), Brazilian pepepertree (*Schinus terebinthifolia*) and Australian pine (*Casuarina equisetifolia*) have found their way into many Florida dune communities. These woody species can cause significant problems and can fundamentally change the structure and habitat quality of dune ecosystems. However, there is a smaller herbaceous up-and-comer called *Kalanchoe* that may cause just as many problems. Along with beach vitex in coastal dunes, this plant may end up being a game changer for management.

*Kalanchoe* is a genus of plants native to the warm, dry regions of Eastern Africa, Southeast Asia, and Madagascar. This plant is in the Crassulaceae family, which is characterized by succulent species possessing special features to deal with hot, dry conditions. These features include succulent leaves, a thick waxy cuticle and a special metabolic pathway to increase $CO_2$ efficiency and reduce water losses. Crassulaceae is a family of plants not dealt with much in aquatics or Florida's natural areas. However, local nurserys and houseplant sections of the grocery store play host to this family including a few species of *Kalanchoe*. Since the late 1800's, many species of *Kalanchoe* have become common around the world due to the ornamental plant trade. They possess attractive succulent foliage, beautiful flowers and are generally easy to propagate. These plants are also exceptionally drought tolerant, meaning they can be ignored as houseplants for weeks or even months and they will generally be fine.

Some of the key species that have gone rogue include chandelier plant (*Kalanchoe delagoensis*) (Figure 1), mother of thousands (*Kalanchoe daigremontiana*) (Figure 2), air plant (*Kalanchoe pinnata*) (Figure 3), and most notably *Kalanchoe x houghtonii*, or mother of millions, which is the focus of this article (Figure 4). As the name implies, mother of millions produces large numbers of propagules. Mother of millions' propagules are not from seed, but come in the form of plantlets produced along the margins of the leaves (Figure 5). These plantlets produce roots while still on the mother plant and drop off with the slightest disturbance, fully ready to grow. These plantlets are the main contributor to the abundance of new growth and offspring produced by this plant as seed production is extremely limited. Therefore, the plantlets

Figure 2: Mother of Thousands, *Kalanchoe daigremontiana*. Leaves are opposite, simple, triangular to lanceolate in shape, serrated margins with plantlets developing on flange-like projections between serrations. Coloration is generally bright green with purple blotching on the under side.

Figure 3: Air plant, *Kalanchoe pinnata*. Leaves are simple to pinnately compound with generally 3-5 leaflets. Leaflets are broadly elliptic with crenate margins. Leaf coloration is light green with reddish margins and stem.

Figure 4: Mother of Millions, *Kalanchoe xhoughtonii*. Hybrid species from *Kalanchoe daigremontiana* and *Kalanchoe delagoensis*. Leaves are simple, lanceolate to oblong with coarsely serrated margin where plantlets develop. Leaf coloration is bright to dark green with dark green to brownish-purple blotching on the underside. The stem varies in color from bright green to dark purple.

**Figure 5: Plantlets with leaves and roots developing on the flange-like projections on the apex of *Kalanchoe delagoensis* leaves.**

serve as the driving force of establishment in dune invasion.

*Kalanchoe* is loaded with poisonous compounds called bufadienolides, which can kill livestock and make pets sick if grazed. It is unknown how gopher tortoises respond to *Kalanchoe* but it tends to form dense patches leaving little room for native species that serve as their food. Possibly most important, this plant species has a very small root system and is a poor stabilizer for dunes. These plants have not been observed yet on large scales in Florida, but this combination of impacts has caused significant issues in other countries worldwide. Florida is still relatively early in the invasion phase, and now is the best time to address this invasive plant.

Several issues make management of *Kalanchoe* complex, the first being location. Invasions are often prominent along pathways through the dunes, and the general public is not too keen on seeing people stomping around in protected areas working to control it. Just stepping past the "keep off the dunes" signs will draw attention. Pulling up plants will earn an earful and spraying plants may earn even more. These potential interactions are why public education on the problem is absolutely critical.

The second major issue for mother of millions is a lack of effective tools that do not exacerbate the problem. Hand pulling appears easy for established plants. They do not possess creeping roots or rhizomes, have very few roots in general, and come up with little effort. The problem lies in the plantlets. They readily fall off during hand pulling and are impossible find. Plantlets also form dense carpets underneath other dune vegetation and can lie hidden and grow for months before popping up through the canopy. In a recent hand pulling event in Saint John's County, nine volunteers worked to remove mother of millions from a heavily infested area in the dunes. In four hours, they successfully removed approximately 200 pounds of plants from an area of only 12 $m^2$. The area was the equivalent of approximately 67,000 pounds per acre, or 33 tons per acre. Volunteers expressed the difficulty of removing all plants and plantlets from under the native vegetation. Once some of the plants with intact roots were removed from the sandy soil, the other smaller plants and plantlets were buried under sand and difficult to see to remove. Also observed by the end of the hand pull event was considerable trampling damage to native plants in area. The hand

**Figure 6: A *Kalanchoe xhoughtonii* shoot tip placed on sand in a greenhouse regeneration study. Left is 24-hours after placement on sand, right is seven days after placement. Within seven days, the shoot tip reoriented towards light, re-rooted, and began producing new plantlets.**

pull area was surveyed 60-days later and it was found that bare spots and damaged native vegetation were still visible, though no large *K. xhoughtonii* plants were observed. On closer inspection, however, the weeded area was heavily infested with new *K. xhoughotnii* plants and plantlets under the vegetation. In some portions of the area, the repopulated patches had approximately 300 plants and plantlets per meter. Though the larger *Kalanchoe* plants were successfully removed, the disturbance caused by the hand weeding in the sensitive and slow growing dune system had potentially allowed for the proliferation of *K. xhoughtonii* plantlets and smaller plants.

A third major issue is regeneration from cut or pulled plants. Recent studies at the University of Florida (UF) have clearly shown whole *Kalanchoe* plants or even small plant parts such as individual leaves can re-root if left lying on sand. Not only can they re-root, they will also continue producing plantlets. A single leaf removed from the parent plant and laid on sand will make a new crop of plantlets even if it fails to root. This discovery means even a weed-whacker and good intentions could greatly spread a small infestation over a large area simply by weed whacking down a patch of the plants. The bottom line is this: any cut or pulled material must be removed from the site. Unfortunately, it is not enough to place the plant on top of other vegetation in the hopes it will dry out, as the plants will continue to produce numerous plantlets before it finally dessicates.

The final issue lies in the use of herbicides. Dunes are often protected and concern exists about using herbicides in sensitive dune areas. Recent research at UF has identified at least three active ingredients that will effectively control *Kalanchoe xhoughtonii*. These include triclopyr, aminopyralid, and glyphosate. All three herbicides controlled established plants and new plantlets, and prevented any new plantlets from being produced. While triclopyr and aminopyralid would be safe to use around sea oats, beach sunflowers and native legumes will likely take a beating. Glyphosate is nonselective and is only effective at very high concentrations, so care must be used when treating this plant with glyphosate. Finally, it is often extremely difficult to effectively treat *Kalanchoe* growing under the canopy of other plants. Spray canopy penetration to the plantlets at ground level is greatly reduced under many native plants, that will also be sensitive to these herbicides. So, bottom line, if the chosen control for this plant is herbicides, spray cautiously.

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# Applicators' Corner

If you're not aware of the press coverage and controversies in Florida regarding algae blooms this past year or so, you must be a recently arrived alien from another planet! Algae blooms and aquatic plant growth are driven by nutrients. The objective of this "Applicators' Corner" is to explain how the nitrogen (N) and phosphorus (P) contents of waterhyacinth and hydrilla are determined and the quantity of nutrients contained in a typical acre of each of these plants. Future columns will assess the utilization of these plants and impacts of harvesting them on water quality.

There are two major factors that need to be known to calculate the amount of N and P (or any element) in a given area of plants. Plant scientists collect these data occasionally and agricultural labs around the country commonly analyze nutrient contents and components of forages and feed for cattle.

The weight of an acre of waterhyacinths is estimated by harvesting a square meter (or other known area) of plants at a typical density in an infested area. Several samples from different areas within the infestation may be collected. The harvested plants are weighed and used to calculate fresh weight per acre. Plants are then dried in an oven at 70 to 80 °C for several days to obtain the dry weight of plants in the sampled area. This dry weight ratio is important because different plants have different water contents and nutrients are reported on a dry weight basis (more on that later), so the nutrient content of various crops or plant species can be compared. A sample of the dried plants is then ground to a fine powder in a specialized grinder. A small sample of this dried powder is then digested in acids or other appropriate substances to remove organic matter such as cellulose and other carbon compounds, leaving only the mineral elements in an acid solution. Samples of this digested solution, which contains N, P and other elements, are then chemically analyzed to determine the content of the minerals in question. After this work is completed, you have the estimated weight of an acre of plants and the amount of N and P in their dried tissue - the two major factors needed to compare nutrient contents of a given area of plants.

Waterhyacinth biomass varies greatly depending upon the size or height of the plants, and values reported in the literature range from 50 to 300 tons of fresh weight per acre. Using a value of 150 tons of fresh weight per acre, the dry weight of the acre can be estimated from the fresh weight/dry weight data collected from the field samples. The water content of waterhyacinths is often 92 to 98%, so for this example we will use 95% water content (5% dry plant material). The fresh weight of an acre of

waterhyacinths is 300,000 pounds (150 tons x 2,000 pounds per ton) and 5% of that is the dry weight of the waterhyacinths, so 0.05 x 300,000 pounds = 15,000 pounds of dry weight per acre. The laboratory report showed that nutrient content of the dried waterhyacinths is 1.61% N and 0.31% P, which are typical average values reported in the literature for waterhyacinth. Thus, this hypothetical acre of waterhyacinth contains (0.0161 x 15,000 pounds dry weight) 241 pounds of N and (0.0031 x 15,000 pounds dry weight) 46.5 pounds of P. The N content of plants is often higher than the P content, and the N content of lake waters is often higher, too (we'll report more on this in the next column). As noted, the biomass of waterhyacinth infestations varies depending on the size of the plants, and the N and P content will also be different when plants grow in waters with higher or lower nutrient concentrations.

Easley and Shirley (1974) reported that the P content of six samples of waterhyacinth varied from 0.17 to 0.66% dry weight. Therefore, the N and P content of an acre of waterhyacinth (241 pounds of N and 46.5 pounds of P per acre) are rough estimates but are useful to compare with other plants such as hydrilla.

The wet weight of undisturbed, uncontrolled, *surface-matted* hydrilla varies less than the biomass of waterhyacinths and since 75 to 80% of hydrilla biomass is in the upper surface (2 feet) of water, hydrilla biomass is largely independent of water depth. Studies have shown that an acre of hydrilla typically weighs between 10 and 15 tons fresh weight, and like waterhyacinth, the water content of the plants' fresh weight is around 95%, depending on how much free water is allowed to drain or is blotted from the freshly harvested plants. In our example, we will use a fresh weight of 12 tons (24,000 pounds) per acre and a dry weight of (0.05 x 24,000) 1,200 pounds per acre. Zimba *et al.* (1993) reported that dried hydrilla from Lake Okeechobee was composed of 3.34% N and 0.19% P, which is within the range reported for hydrilla in other studies. Using these nutrient values and a dry weight of 1,200 pounds per acre, the N content of hydrilla is (0.0334 x 1,200) 40 pounds per acre, and the P content of hydrilla is (0.0019 x 1,200) 2.28 pounds per acre.

In conclusion, while the amounts of N and P in waterhyacinth and hydrilla are similar (although N is higher in hydrilla), the major difference in the nutrient contents of an acre of these plants is due to the much higher (12.5x) biomass of waterhyacinths vs. hydrilla. In the next issue of *Aquatics*, we will examine the magnitude of these N and P values in comparison to water and sediment concentrations, and space permitting, we will review the potential uses for harvested plants. Note: the acre estimates of N and P contents of these plants will vary greatly depending upon the weight per acre and the nutrient content of the environment in which the plants are growing.

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Brazilian peppertree encroaching on native scrub habitat in Cape Canaveral.

# Progress in the struggle against Brazilian peppertree

**Stephen Enloe and MacKenzie Bell,**
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Brazilian peppertree or peppertree is one of the most widespread, widely recognized and widely managed invasive plants in Florida. Few natural area managers in Florida have had the luxury of avoiding projects involving this invasive tree. Peppertree has become one of the most costly and devastating invasive plants in the state. Peppertree occupies several hundred thousand acres in the peninsula and invades a myriad of natural areas including sand dunes, coastal scrub, pine rocklands, hydric hammocks, upland pine forests, flatwoods, strand swamps, mangrove forests and disturbed areas. This invasive plant outcompetes native vegetation through its aggressive growth habit and dense shading canopy, alters fire frequencies, and ultimately degrades habitats upon which Florida's unique fauna depend. Managing peppertree is a top priority in the effort to conserve Florida's natural areas.

Unfortunately, controlling peppertree is not an easy task. Peppertree is in the same plant family as poison ivy and can cause skin rashes. Dense stands of peppertree will often not carry prescribed fires, and, if it does burn, the plant sprouts back vigorously from the trunk or from lateral roots. The same sprouting response is observed when peppertree is mown or cut.

The biological control agent, Brazilian peppertree thrips (*Pseudophilothrips ichini*) was released in the summer of 2019. The insect selectively feeds on the new stem and leaf tissue and is expected to help reduce the plant's growth and reproduction. This biological control could be a major advance in reducing overall management costs long-term; however, time will be required to determine the full impact. In the meantime, additional management efforts are still warranted in most areas.

Given its proclivity to resprout following fire or cutting, land managers primarily rely on herbicide treatments. Much of this is ground based crews using individual plant treatment (IPT) approaches. The treatments include foliar, cut stump, and basal bark. For many years now, basal bark application with triclopyr ester applied at 20% volume to volume (v/v) in an oil carrier has been widely used. This approach entails carefully spraying the herbicide oil mix on the bark around the base of the tree to a height of 12 to 15 inches up the trunk. This technique is very selective and effective, but peppertree often has complex stem architecture with multiple stems arising from the base of the tree. Since each stem must be fully treated, the surface area requiring treatment on a multi-stemmed peppertree results in a high application volume of the oil-herbicide mix. This can quickly approach or exceed the eight pound acid equivalent per acre maximum label rate of triclopyr ester.

To address this issue, studies were conducted to develop alternative tools and techniques that will assist land managers in peppertree management. These studies include research on new herbicide formulations including triclopyr acid (Trycera), aminopyralid (Milestone), and aminocyclopyrachlor (Method 240 SL) using traditional IPT techniques in addition to a novel hack and squirt approach also known as "incision point application" per Dr. James Leary of the UF/IFAS Center for Aquatic and Invasive plants.

About one dozen studies were con-

ducted over the last four years at multiple sites in Florida, from Cape Canaveral Air Force Station to sites west of Miramar, on the edge of the Everglades. Studies were focused on testing the newer herbicides with the typical IPT techniques. These studies generally involved treating hundreds of trees and then monitoring them for up to 18 months to assess treatment performance. The work was conducted under extremely difficult conditions in peppertree forests where tunnels were cut through the sites to be able to treat and monitor. Additionally, contractors were invited to help implement larger studies where the control work was performed by contractor crews. Scaling up efforts to ensure operational feasibility is critical for success.

What was learned in these studies? For cut stump work, the main conclusion was it is extremely difficult to do. Cutting large, twisted, multistemmed peppertrees can be very hazardous and kickback of limbs under immense pressure is extremely dangerous. In many cases, twisted trees kicked back in bizarre, unpredictable directions, which created a hazardous situation for the sawyer. Full chainsaw safety gear is strongly recommended when cutting peppertree. Additionally, even large trunks left on the ground after cutting tended to re-root and produce new trees. Regarding newer herbicide treatments, both aminocyclopyrachlor (Method 240 SL) and aminopyralid (Milestone) worked extremely well, at 10% volume to volume when mixed with water. Both herbicides resulted in approximately 95-100% kill at this concentration. Both herbicides also worked well at 5% v/v, providing 89-95% kill. Triclopyr acid at 50% v/v was as effective as triclopyr amine at 50% v/v; both resulted in 89-95% kill. Bottom line: Cut stump treatment is definitely a least favorite technique, but there are now options that can cut herbicide use rates significantly compared to the commercial standard of triclopyr amine at 50% v/v.

Basal spray application on peppertree.

For basal bark work, it was observed imazamox (Clearcast), a water soluble herbicide labeled for basal bark treatment, when mixed with Impel Red basal oil, sprays out like cotton candy. This herbicide is not recommended as it tends to gum up the sprayer. Imazamox is a very useful herbicide for many other invasive problems, but other options not quite so hard on the equipment exist. Investigators also found aminocyclopyrachlor (Method 240 SL) was effective at 5% and 10% v/v. The primary issue for Method is a maximum labeled rate of 18 ounces per acre. This rate will be a problem in high stem density areas.

Triclopyr acid (Trycera) applied in Impel Red basal oil, resulted in 100% kill at both 10 and 20% v/v. These results were comparable to the commercial standard triclopyr ester treatment at 20% v/v. Given Trycera is formulated at 2.87 lb acid equivalent per gallon, 10% v/v treatment is actually a triclopyr acid equivalent reduction of almost 65% from the triclopyr ester treatment. This result is very noteworthy if the target is effective control with reduced herbicide. However, there is a tradeoff, as control with Trycera is best achieved by applying a heavier application of the herbicide oil mix to a higher band height of at least 18 inches. This application results in a pretty sizeable increase in oil carrier used, which results in an increase in cost. The Trycera label also carries the 'danger' signal word due to potential eye injury issues. Therefore basal bark applicators accustomed to the 'caution' signal word of triclopyr ester need to pay special attention when shifting to this product.

For our incision point application work, (a.k.a. reduced hack and squirt), Method mixed at 50% v/v in water and applied at 1 ml to a single hack per tree killed trees between three and four inches in diameter. Milestone mixed at 50% v/v in water applied at 1 ml to a single hack per tree killed trees approximately two inches in diameter. For multistemmed trees where stems were four inches in diameter or less, ***one single hack and squirt to each stem*** on the tree was sufficient to kill the entire tree with either herbicide.

This study was then scaled up to the contractor level and developed using a

soda bottle for stem size determination. A two liter soda bottle was used to train applicators to estimate stem diameter sizes since it is exactly four inches in diameter and the cap is one inch in diameter. For large multistemmed trees, applicators were trained to ignore stems less than one inch in diameter, make one hack for stems one to four inches in diameter, and make two hacks for stems four to eight inches in diameter. Investigators tested both Milestone and Method with this approach at 50% v/v each applied at 1 ml per hack. Applicators also compared these hack and squirt approaches to basal bark treatment with either Trycera at 10% v/v or Triclopyr ester at 22.%% v/v.

At 18 months after treatment, Method resulted in approximately 90% mortality, which was comparable to either basal bark treatment approach. Milestone was less effective, resulting in approximately 60% kill. The reduced efficacy by Milestone tied back nicely to the previous studies and the protocol for Milestone will need to be subsequently adjusted for peppertree. However, Method performed well under these specifications and is currently fully labeled for this approach.

Investigators also found incredible variation in the spray output of different spray bottles. A separate study of about a dozen different spray bottle brands found a range of outputs from slightly less than 1 ml per stroke all the way up to 3.5 ml per stroke, which is a big difference. As a result applicators need to pay close attention to spray bottle outputs when performing any type of hack and squirt treatment. Excess herbicide solution running out of the hacks and down the stem is not useful and results in wasted herbicide.

To summarize, aminopyralid, aminocyclopyrachlor and triclopyr acid all have significant potential to control Brazilian peppertree with IPT techniques. They can also all be used at concentrations lower than the commercial standards. This use can result in reduced herbicide inputs into the environment while still effectively controlling peppertree. However, it will still be important for applicators to follow all label instructions and stewardship guidelines when using these herbicides. Be on the lookout soon for new UF/IFAS EDIS documents fully describing these new approaches!

Reduced hack and squirt application on peppertree.

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# Approaches to Managing Cyanobacterial Blooms and Altering Water Quality

*Dolichospermum crassum* (Lemmermann) Wacklin, Hoffmann et Komárek. Photo by W.M. Bishop


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In the previous *Aquatics* Issue (Fall 2019), an overview of cyanobacterial blooms was published as well as a look at their toxins, exposure routes and associated health effects (*Cyanobacterial blooms in Florida's fresh waters* by Lefler *et al.*, 2019). With the increased awareness of these blooms, and the potential for harming humans and wildlife through many exposure routes, we thought a follow-up article regarding management approaches that are commonly used was warranted. However, we want to start by stressing that **any** product or device that is used or implied to control algae (including cyanobacteria for this article) must be registered by the USEPA under FIFRA (Federal Insecticide, Fungicide and Rodenticide Act).

In this article, we cover a broad overview of some approaches to water resource management. Management can be broadly categorized into proactive and reactive approaches. Proactive approaches are designed to alter the aquatic system to improve water quality, which could offset the potential for bloom formation. Reactive approaches are more focused on directly addressing the nuisance organisms once present. Very often, both categories may be applied in an integrated approach. **Table 1** provides a general listing of some proactive and reactive categories for management.

Some of the most common water resources management methods specifically used to offset cyanobacterial growth are listed below. This list is not exhaustive, nor could significant detail be provided in a short article. The list is also not intended to promote any specific product or approach. Importantly, site-specific conditions and objectives must be considered in selecting a management approach or integration thereof.

**Table 1. Proactive and Reactive approaches to cyanobacterial bloom prevention and treatment***

| | Proactive | Reactive |
|---|---|---|
| Chemical | Nutrient mitigation, water quality enhancers, dyes | Registered algaecides, dyes, flocculants, polymers, coagulants |
| Physical | Barriers, watershed alteration/regulation, stormwater control measures | Raking, skimming, shade cloth/balls, flushing |
| Mechanical | Aeration, oxygenation, fountains, artificial mixing, withdrawal, dredging, harvesting, skimming | Sonication, ultraviolet light, cavitation, ozonation, superoxide, electrolysis |
| Biological | Biomanipulation of the food web, microbes, native plant establishment, floating islands, constructed wetlands, buffers | Plant extracts, enzymes, microbes, planktivorous fish, invertebrates |

* Note: Any product or device that claims or implies to mitigate a pest must be registered under FIFRA by USEPA. C. Layne provided a wonderful explanation of this in his *Aquatics* article *Alum Revisited*.

## Chemical

Chemical means of management are targeted towards the biological pest itself or the nutrients that nourish the bloom. Flocculants, polymers, and nutrient binding tools mainly help by targeting water quality related aspects, while algaecides and dyes work by directly affecting the algae. Thus, these methods can be for water quality treatment (proactive) or the direct treatment of cyanobacteria (reactive).

*Flocculants, Polymers, Nutrient binding tools*

Water treatment methods that clarify the water column (e.g. polymers, clay, chiton, aluminum compounds) and/or bind nutrients, such as phosphorus (e.g. aluminum/iron/calcium salts, lanthanum modified bentonite) can work rapidly with favorable results. Nutrient mitigation must be acknowledged in management of blooms; binding and inactivation of nutrients are especially important as nutrients, such as phosphorus, can be cycled internally in a water body from the sediment or decomposing matter. Nutrients sustain blooms, and their reduction in a cost-effective manner, if feasible, is a vital way to mitigate the bloom. However, be careful of claims, since these substances may require a pesticide registration if the intended use is to suppress or mitigate algae.

**Photo of a *Microcystis aeruginosa* (Kützing) Kützing dominated bloom. Photo by W.M. Bishop**

*Algaecides*

Algaecides contain chemical compounds formulated and registered (USEPA under FIFRA) for use to control algae at specific use sites with labels that must be strictly followed. They are typically fast acting with a main active ingredient that often includes copper salts, chelated copper, peroxides, diquat, or endothall. All algaecide label instructions are designed to limit risks to humans and the environment when used in the proper manner and following listed application rates. There are many recent formulations besides copper sulfate suitable for a variety of application styles (liquid, granular, etc.) with potential increased efficacy and less risks to non-target organisms. The disadvantages of algaecides are that they often target the integrity of the cyanobacterial cell, and once lysed, these cells may release toxins into the dissolved state in water. However, total toxin, of which many risks are associated, decreases with an effective treatment.

Algaecides are short-term solutions, unless nutrient loading is also addressed in management efforts. Algaecides can also be taxon-specific, where they target only some taxa of algae, while leaving others untouched. The potential for algaecides to affect non-target species is something to consider, therefore always follow label rates.

Dyes are chemicals used to physically block specific wavelengths of sunlight that certain groups of algae use for photosynthesis. Different dyes (e.g. black, blue) can absorb light at wavelengths that may align with the target nuisance algal pigments (e.g. phycocyanin, chlorophyll *a*). These can be cost-effective but must be applied in the proper context of the nuisance algae and following label rates and regulations (only some dyes are registered algaecides).

## Biological

*Biomanipulation*

Managing algal blooms can also take form in the manipulation of biological aspects of aquatic systems in order to reduce nutrient levels and/or promote beneficial species food-web interactions. Biomanipulation can be in the form of the introduction of species (e.g. stocking predators, herbivores, or native plants) or nutrient

**Photo of a *Microcystis wesenbergii* (Komárek) Komárek ex Komárek dominated bloom. Photo by D.E. Berthold**

manipulation (e.g. the addition of nutrients to change the Redfield ratio and attempt to select for beneficial algal taxa).

Introduction of a species by stocking predators or native plants can be an effective water management strategy. Some algal types are preyed on by certain species (e.g. *Daphnia*, planktivorous fish). Several plants, including species of *Typha*, *Elodea*, *Vallisneria* and the macroalga *Chara* take up nutrients, stabilize sediments, and produce allelopathic compounds that can be used for water quality control. Although useful, biomanipulation is complex with many factors involved. Species introduction, for example, must account for the accidental introduction of invasive or exotic species and the overall environmental impact. Introduced organisms have their own biology, ecology, and natural history that must be considered to be effectively implemented.

*Microbes, enzymes, extracts*

Microorganisms (including bacteria, fungi, and viruses) can offer many services when dealing with algal blooms. They can be used to outcompete algae in attaining nutrients, reduce nutrient mobility, or produce enzymes (e.g. cellulases, proteases) that physically or physiologically affect algal growth. There are few peer-reviewed data available on how adding microorganisms influences an aquatic system, but some anecdotal stories of success in the field have been reported.

Using extracts from plants can also ameliorate water quality. Extracts, including those from barley straw, rice husk or peat moss, are used to inhibit algal growth and survival through the release of a variety of known and unknown chemical substances (e.g. phenolic acids, flavonoids, hydrogen peroxide). Many claims seem intended to suppress or mitigate algae, therefore these released compounds may need USEPA registration under FIFRA.

## Physical

*Raking, Skimming, Shading*

Algal blooms at times form large cohesive mats and removal of this bloom by raking can be effective but is time and energy intensive and can also result in the spreading of fragments. When the algal bloom forms an amorphous layer over the water surface, skimming off the biomass can also be an effective removal method. Other physical methods of combating blooms involve shading out the sunlight to decrease photosynthesis. Shading can be carried out using shade cloth or balls, or in a chemical manner using dyes.

*Flushing*

Removal of algal biomass through flushing demands large volumes of water and often high energy and capital costs to implement. Also, there are potential discharge regulations to consider and negative downstream impacts that may occur (e.g. depletion of dissolved oxygen, toxins).

*Watershed Management*

Freshwater aquatic environments are typically a function of their watershed and land use. Watershed management is an integrative approach that implements plans and projects for the sustainable use of watersheds, to improve water quality and supply. Protection of a water body can

be accomplished through land-use modifications, such as the use of stormwater retention ponds, sustainable agriculture, constructed wetlands, buffer areas, and following best management practices to offset nutrient runoff. Watershed management is fundamental for the long-term reduction of nutrients, which can fuel algal blooms.

## Mechanical

Mechanical means of managing algal blooms often include dredging, sonication, aeration, harvesting and oxygenation. Dredging removes the benthic sediments, thus limits the resuspension of legacy nutrients, but can be expensive due to machinery, labor and disposal, and is not practical for many water bodies. Aeration and oxygenation using fountains, mixers, or nanobubblers involves mixing the water column and/or addition of gases to promote high oxygen levels and aerobic decomposition, altering the biogeochemical nutrient cycling. However, mixing of the water column may introduce sediment nutrients into the water column, add more CO2 for algae, and promote environments for algae that are adapted to mixed conditions. Although potentially effective, most mechanical methods require a power supply or energy to run and must be sized correctly and maintained appropriately for each site, which ultimately increases costs.

## Concluding

In summary, with the growing threat of cyanobacteria and cyanotoxins, all management approaches should be considered. Knowledge of the pest and site-specific characteristics and objectives are fundamental in establishing a management approach, and science-based data on all management options are imperative. We sought to provide a general overview of many options and some of the associated benefits and risks.

**Photo of 'floating mats' dominated by the benthic cyanobacterium *Microseira wollei* (Farlow ex Gomont) G.B.McGregor & Sendall ex Kenins. Photo by D.E. Berthold.**

***Dail Laughinghouse, Ph.D. (hlaughinghouse@ufl.edu)*** *is an Assistant Professor of Applied Phycology and State Extension Specialist in Algae at the University of Florida/IFAS. Dr. Laughinghouse is also a Florida Sea Grant Extension Specialist in Harmful Algal Blooms. He is a broadly trained phycologist working with both basic and applied algal research from tropical to polar regions for roughly 16 years. His research background includes work on taxonomy, systematics, evolution, toxicity and ecology of aquatic and terrestrial cyanobacteria and algae; harmful algal bloom (HAB) monitoring and mitigation; phycoremediation; and metagenomics and metatranscriptomics of marine, freshwater and terrestrial environments.*

***David E. Berthold, MSc (dberthold@ufl.edu)*** *is a Biological Scientist III working with Dr. Laughinghouse at the University of Florida/IFAS and also a PhD candidate focusing on the study of cyanobacteria and diatoms. He has worked with algae for over 8 years, focusing on the diversity and systematics of aquatic and terrestrial cyanobacteria, chlorophytes, and diatoms; biomass and lipid production by algae; HAB monitoring, mitigation and toxicity; and genomics and transcriptomics. Mr. Berthold also curates the BLCC algal culture collection, with almost 500 unialgal/unicyanobacterial strains.*

***West Bishop, Ph.D., CLP (westb@sepro.com)*** *has been researching algae for roughly 13 years. Dr. Bishop has been working for SePRO Corporation for over 9 years as their Algae Scientist and Water Quality Research Manager. His focus is on developing and supporting new solutions for managing nuisance algae and improving water quality. Dr. Bishop also hosts an informational video series entitled, Algae Corner.*

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# Rapid Response Hydrilla Management Alleviates Flooding in Lake Panasoffkee Outlet River

Dean Jones (Biologist, University of Florida Center for Aquatic and Invasive Plants) setting up endothall injection lines on a dock at the Lake Panasoffkee Outlet River in 2019.

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**Dean K. Jones,**
*(kdjones@ufl.edu), Biological Scientist, University of Florida Center for Aquatic and Invasive Plants, Lake Alfred, FL.*

**Brian Nelson,**
*(Brian.Nelson@swfwmd.state.fl.us), Vegetation Management Manager, Southwest Florida Water Management District, Brooksville, FL.*

**Bruce V. Jaggers,**
*(bruce.jaggers@MyFWC.com),Invasive Plant Management Biologist, Florida Fish and Wildlife Conservation Commission, Inverness, FL.*

**James K. Leary, Ph.D.**
*(learyj@ufl.edu), Assistant Professor, University of Florida Center for Aquatic and Invasive Plants, Gainesville, FL.*

Lake Panasoffkee (~5,750 acres), located in Sumter County, Florida is a naturally groundwater charged lake that connects to the Withlacoochee river through an outlet river (Figure 1; McBride et al. 2011). The outlet river allows water to flow out of the lake and into the Withlacoochee river when lake levels are higher than river levels. In August of 2019, the Southwest Florida Water Management District (SWFWMD) and the Florida Fish and Wildlife Conservation Commission (FWC) received several phone calls from stakeholders reporting flooding concerns near Lake Panasoffkee which spurred an investigation of the lake levels (Figure 2). Based on historical water flow data for periods of similar lake and river water levels, SWFMD hydrologists calculated discharge rates in the outlet river needed to be near 400 cubic feet per second

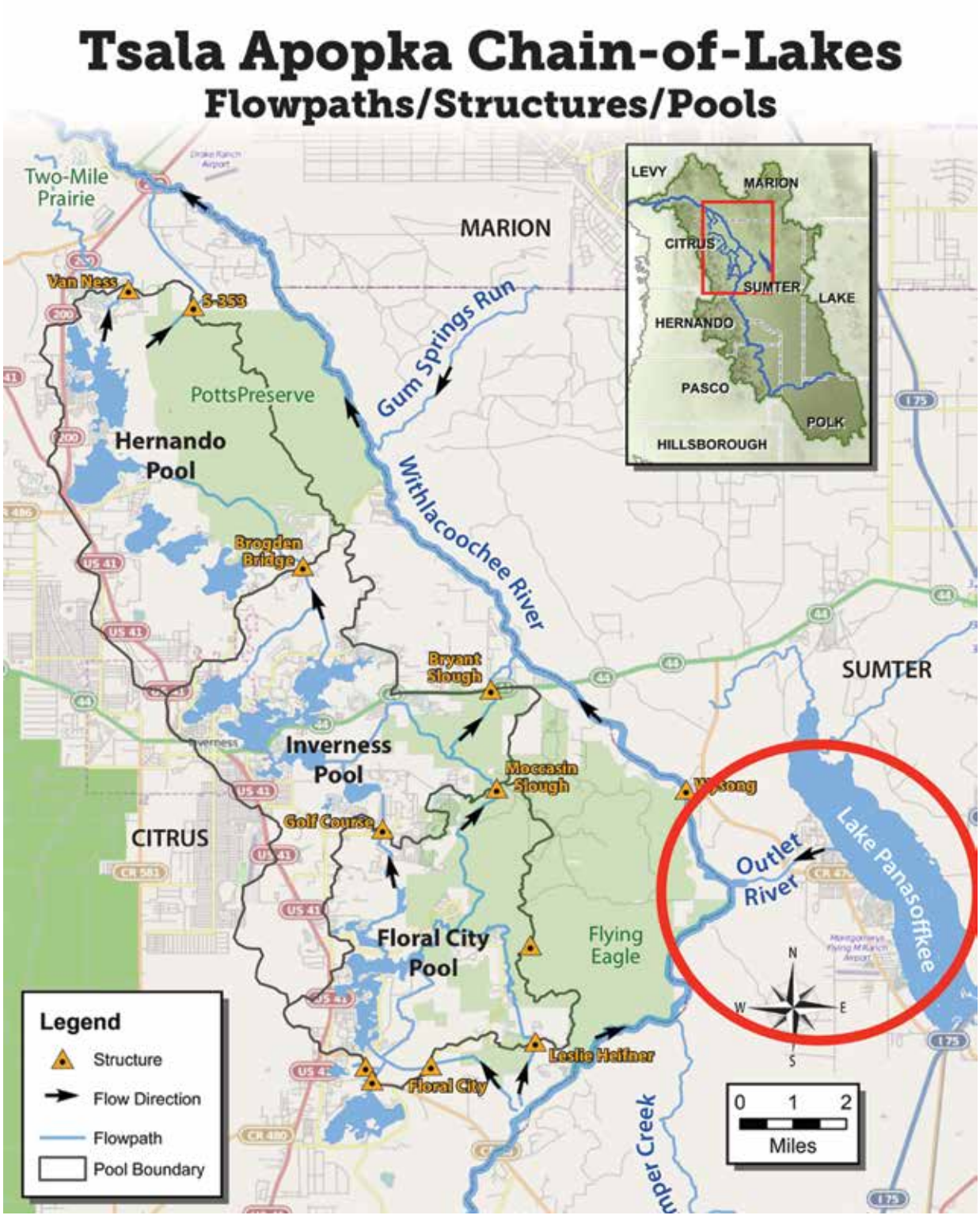


**Figure 1. Map of the Tsala Apopka Chain-of-Lake in which Lake Panasoffkee and the Outlet River are located.**

(CFS) to maintain appropriate water levels in Lake Panasoffkee. However, when measured, discharge rates in the outlet river were only around 200 CFS, which helped explain why Lake Panasoffkee's water level was the third highest recorded since 1960 (Figure 3).

Hydrilla (Hydrilla verticillata) is one of the most problematic weeds in Florida and has the potential to completely fill a waterbody when left unmanaged which can severely constrict water flow, particularly in rivers (Gettys and Enloe 2016, Langeland 1996). Further investigation indicated the primary cause of reduced discharge rates was due to dense infestations of hydrilla that covered 98% of the water surface and occupied 66% biovolume for several miles of the outlet river (Figure 4). During this time, hurricane Dorian had developed into a category 5 storm and the State of Florida was in its predicted path. With Lake Panasoffkee already experiencing flooding conditions, additional rainfall from one of

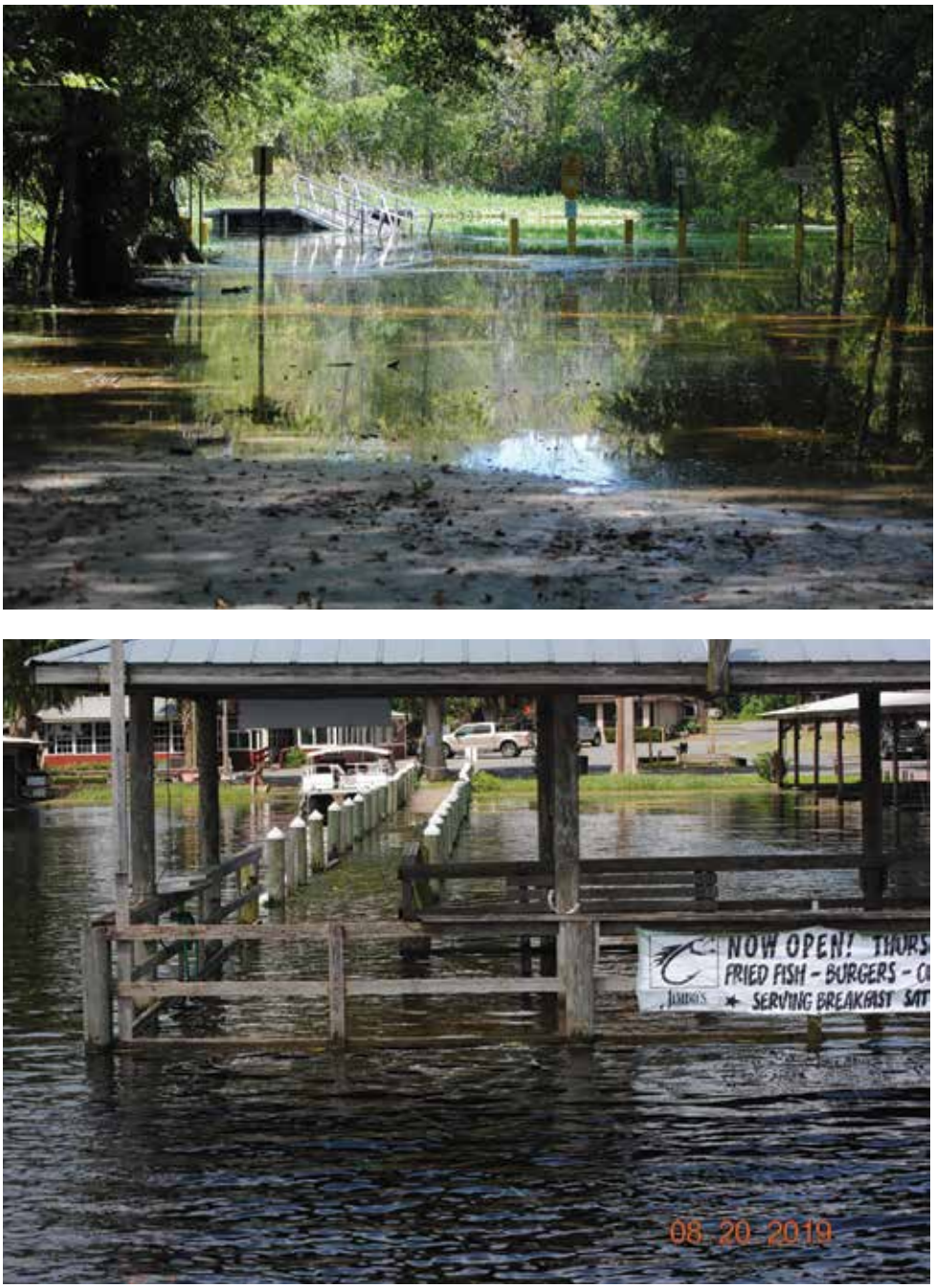


**Figure 2. Flooding conditions due to restricted water flow on the Lake Panasoffkee Outlet River in 2019.**

the most powerful hurricanes in history posed tremendous threat to people and property of the area. Acting fast, Brian Nelson (SWFWMD Vegetation Management Manager) and Bruce Jaggers (FWC Invasive Plant Management Biologist) partnered with the University of Florida to develop a rapid response plan to rapidly reduce hydrilla biomass. It was determined by the team of collaborators that an approach integrating herbicide treatments and mechanical harvesting would be optimal to secure this high-risk situation. With no time to wait, team leaders addressed logistical issues and gained approval for funding to expedite a management plan. Moreover, this project required stakeholder support. The Pana Vista Lodge located on the outlet river was critical in providing a staging area to base operations and further provided watercraft support to successfully complete the mission.

Herbicide treatments are highly effective in controlling hydrilla at low concentrations; however, herbicide concentrations need to be maintained for a specific period of time (i.e. exposure time) in order to work. Exposure time requirements of aquatic herbicides are easily accomplished in semi-closed lake systems with low discharge rates but treating the outlet river would be unlike most applications made in Florida lakes since a flowing system does not allow for significant herbicide residence time. After evaluation of the system's discharge rates, target plant species, and sensitivity of the situation, the working group concluded a special technique commonly referred to as "drip" or "injection" herbicide application would be needed.

The "drip" technique involves low-output electric peristaltic pumps, similar to those used for administering intravenous medications, used to slowly inject a metered amount of herbicide into the water for a calculated period of time (Sisneros et al. 1998; Figure 5). Based on concentration-exposure time requirements developed by scientists at the US Army Corps of Engineers – Engineer Research and Development Center, the herbicide that would be most appropriate for this scenario was endothall (Aquathol K®, dipotassium salt of endothall, UPL, King of Prussia, PA). Research has shown that four parts per million (ppm) of endothall and an exposure time of 12 hours can provide adequate suppression of hydrilla (Netherland et al. 1991). Treatment was initiated the morning of August 20, 2019, and encompassed 2.52 miles of the outlet river totaling 41.8 surface acres.

A primary concern in planning this operation was that the large biomass of treated hydrilla in the river would be uprooted and swept downstream by the swift current, potentially causing a vegetation jam on the County Road 470 bridge. This could have further restricted water flow in the river, exacerbated flooding conditions on Lake Panasoffkee, and obstructed navigation. For these reasons, treated hydrilla on the portion of river upstream of the bridge was mechanically harvested beginning on August 21. By August 22 (two days after treatment), discharge rates in the outlet river increased from 200 to almost 250 CFS and increased to nearly 500 CFS on August 26, only six days after treatment (Figure 3). At six days after treatment plant coverage and biovolume in the treated area

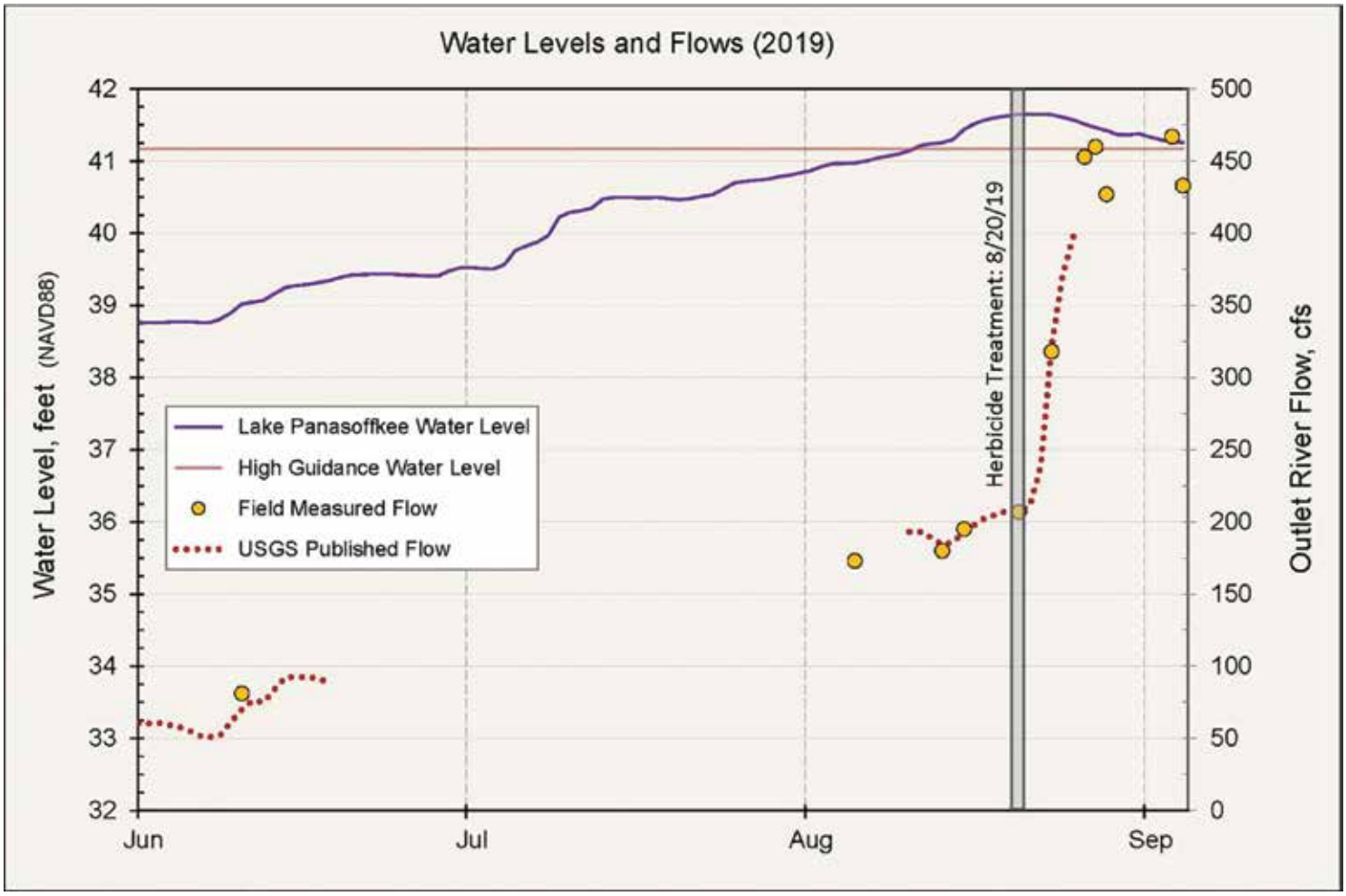


Figure 3. Water levels and flow rates of the Lake Panasoffkee Outlet River between June and September 2019. Gap in USGS published flow rates were due to flow meter malfunction. Figure created by Mark Fulkerson, Ph.D., P.E., Southwest Florida Water Management District.

Figure 4. Hydrilla infestation on the Lake Panasoffkee Outlet River that caused reduced water flow to the Withlacoochee River resulting in flooded conditions in 2019.

**Figure 5. Endothall (Aquathol K, UPL) injection system for the Lake Panasoffkee Outlet River in 2019.**

were reduced to 92% and 30%, respectively. This integrated approach to hydrilla management was successful in an emergency situation with overall water levels in Lake Panasoffkee dropping approximately 18 inches by September 20.

The critical situation averted on the Lake Panasoffkee outlet river was a good reminder of how important it is to protect our waters from the harmful impacts of invasive plants. Fortunately, the disaster that could have occurred from this hydrilla infestation was alleviated quickly. Additionally, this rapid response intervention was an excellent example of the success possible through cooperative effort of several organizations to quickly and efficiently solve a problem to preserve human safety.

The mission of CAIP is to develop and disseminate strategies for addressing the impact of invasive plants. For more information about the UF/IFAS Center for Aquatic and Invasive Plants please visit https://plants.ifas.ufl.edu. Be sure to follow us on social media @UFIFASCAIP. UF/IFAS CAIP, Turning Science Into Solutions.

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*Assistant Research Scientist, Benjamin Sperry, Ph.D, (bpsperry@ufl.edu) is a faculty member at the University of Florida's Center for Aquatic and Invasive Plants and an IPA member of the USACE Chemical Control Team.*


# Weed Science T-shirt Winner!

To win the t-shirt I read the "Applicators' Corner" section of Aquatics and submitted three responses to Dr. Lyn Gettys about a mystery plant and photo. I knew hydrilla turions and tubers, AKA "axillary turions" and "subterranean turions" respectively, were in the mystery photo based on four years of sediment sampling. The article was entertaining and informative so I would have quickly entered even without years of tuber bank sampling. Aquatic plant research from Florida helped inform Ohio's management effort and I will wear my shirt with pride. Thank you!

*Mark Warman, mjw1@clevelandmetroparks.com, is the Aquatic Invasive Species Project Coordinator for Cleveland Metroparks and works on an Early Detection and Rapid Response project to identify and manage aquatic invasive plants in Ohio's Lake Erie Basin. Initially funded by the Great Lakes Restoration Initiative (GLRI), grant funding for the project is now administered jointly by the Ohio Department of Natural Resources and U.S. Fish and Wildlife Service viafrom the GLRI Program. Mark's increasing number of grey hairs are due in part to Hydrilla, Hydrocharis morsus-ranae, Butomus umbellatus, and Nymphoides peltata.*

# Protecting Casselberry's Lakes with Low Impact Development

Lake Concord Park during an outdoor music event. Pervious paving areas and the park's largest rain garden (with cypress trees) can be seen on the lower right side of the photo.

To help protect its lakes and streams, the City of Casselberry has been using "**Low Impact Development**" (LID) techniques in its public projects for over ten years. LID attempts to reduce environmental impacts through a variety of methods that help stormwater runoff percolate into the ground rather than discharging directly to a receiving waterbody, such as a large detention pond or lake.

Conventional land development often completely strips a development site, removing all (or nearly all) trees and vegetation, completely re-grading the site, adding significant impervious area (e.g., concrete, asphalt), and installing a system of inlets and drainage pipes to collect and move stormwater. **LID is different.** LID attempts to reduce the amount of disturbance and re-grading of a site, which can help preserve canopy trees and maintain natural drainage patterns. LID often uses special techniques such as **pervious pavement, rain gardens, and bioswales** to capture and treat stormwater runoff, allowing it to infiltrate slowly into the ground just like nature does. In addition to protecting water quality, LID can help reduce flood risk.

In 2009, the City of Casselberry constructed **Lake Concord Park**. This park was designed to be a showcase exemplifying LID techniques and stormwater best management practices (or "BMP's"). Re-grading of the site was minimized in order to preserve mature live oak trees. Rain gardens were installed and planted with Florida-friendly landscaping to collect and treat stormwater. Three different types of pervious pavement were used to reduce runoff from the parking lot. Swales (shallow ditches) were installed upland of the lake shoreline to intercept and treat stormwater runoff from sidewalks. **Shorelines were replanted with native plants** to restore habitat and provide additional treatment of runoff. The park also features **stormwater "harvesting"**, which reuses stormwater for irrigation, further reducing discharge

of pollutants to the lake system. In the case of Lake Concord Park, stormwater is pumped from a nearby wet detention pond to provide the primary source of irrigation for the park.

The concepts behind LID can also be used to help **restore previously developed sites** so that they function more like their original natural condition. A recent example of this was the City's Casselton Drive Improvements Project, completed in late 2019. Casselton Drive is located near the southern end of Casselberry and parallels SR 436. Although only a two-lane road, Casselton's pavement was about 50 feet wide, and yet it lacked complete sidewalks. The project **narrowed the road** by more than half, freeing up space for a wider and more complete sidewalk network. This also **freed up more area for green space**, including rain gardens and bioswales that are beautifully landscaped with canopy trees and Florida-friendly flowers, groundcovers, and shrubs. In addition to capturing and treating runoff, these features also create a "linear park" feel, providing a new recreational amenity to the surrounding neighborhoods and businesses. The project resulted in a **reduction in impervious area** of over half an acre. This reduction alone (before even considering stormwater treatment improvements) eliminates over 50,000 gallons of runoff from being produced in a major storm event. Instead of flooding and polluting downstream waters, more rainfall can now simply percolate into the soil, providing **natural irrigation and helping replenish groundwater supply**.

Two children participating in the Butterfly Release at Earth Fest.

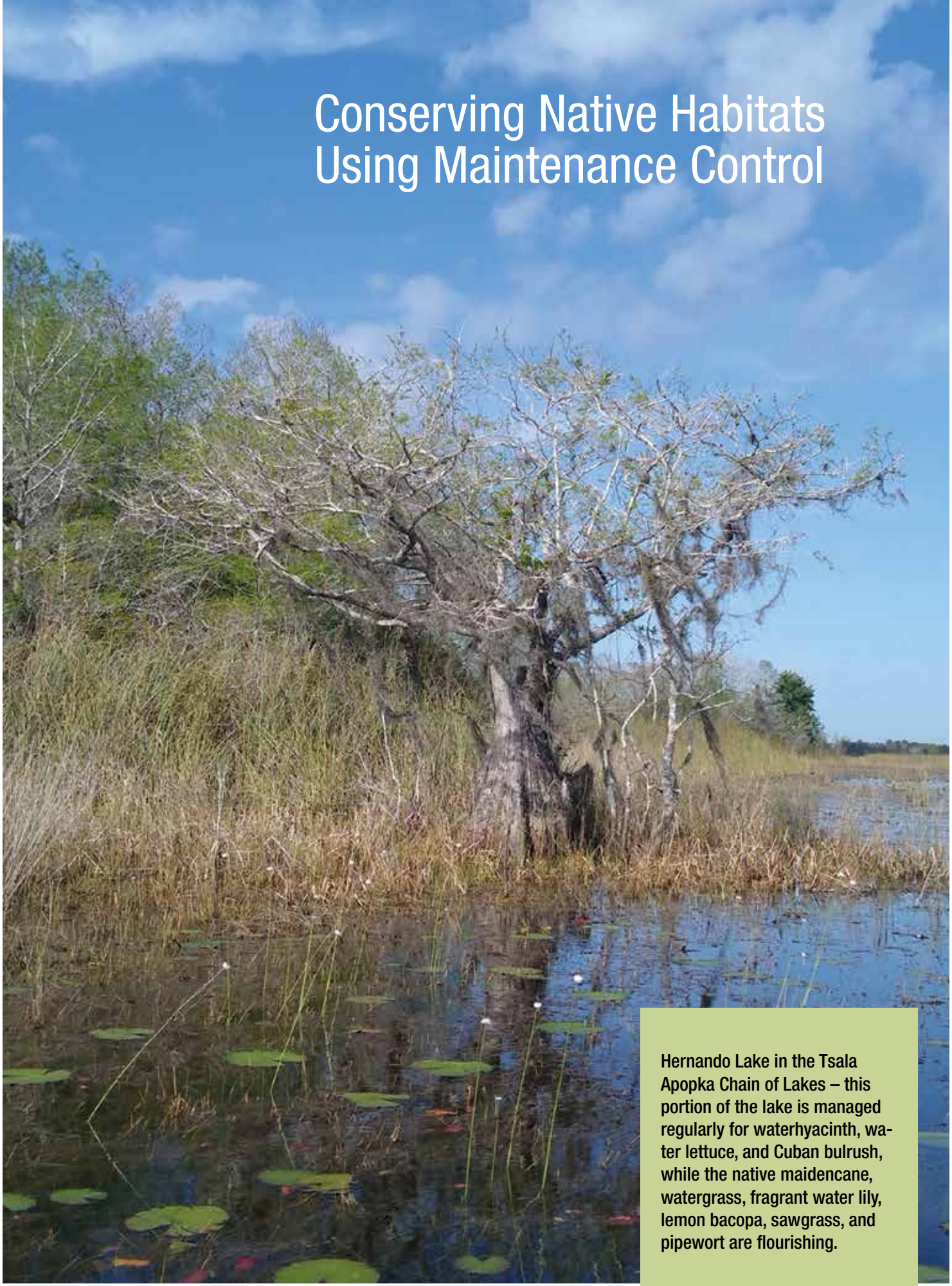
More projects like Casselton are currently under design, including Lake Kathryn Circle and Sunset Drive, which are anticipated to begin construction in late 2020 and early 2022, respectively.

In addition to projects, the City also works hard to inform residents and visitors about environmental issues, including LID and BMPs. For example, Lake Concord Park also features extensive educational signage to provide visitors information about its many environmentally conscious features. In addition, every April the City hosts Earth Fest at Lake Concord Park, the second largest Earth Day event in Central Florida, drawing thousands of visitors. This event doubles as the City's Arbor Day Celebration. At it, visitors can attend short educational sessions covering a range of topics, including tree care and Florida-friendly landscaping. Hundreds of free trees and plants are given away each year at the event. The next Earth Fest will be held on April 18, 2020 from 10 a.m. to 3 p.m.


Pictured here are "before" and "after" photos of Casselton Drive looking south. Bioswales and rain gardens can be seen on the right side of the "after" photo between the sidewalk and road.

*Dr. Kelly Hans Brock earned his doctorate in Agricultural & Biological Engineering from the University of Florida. Dr. Brock has worked as City Engineer for the City of Casselberry since 2007, where he manages capital and maintenance programs in stormwater, lakes, parks, transportation, and more. He is a registered Professional Engineer in the State of Florida, a Certified Floodplain Manager, a LEED Accredited Professional, and an Envision Sustainability Professional. Dr. Brock was instrumental in the completion of the award-winning Lake Concord Park, a stormwater BMP showcase that has become the cultural center of the City. In addition, he has led efforts to promote complete streets in the City – enhancing landscape, walkability, bike-friendliness, safety, accessibility, and sense of place. Dr. Brock played a key role in developing the City's first ever Multimodal Transportation Master Plan, as well as its latest Stormwater and Lakes Management Master Plan. Dr. Brock can be reached at kbrock@casselberry.org.*

# Conserving Native Habitats Using Maintenance Control



Hernando Lake in the Tsala Apopka Chain of Lakes – this portion of the lake is managed regularly for waterhyacinth, water lettuce, and Cuban bulrush, while the native maidencane, watergrass, fragrant water lily, lemon bacopa, sawgrass, and pipewort are flourishing.

Lake Kissimmee – Philadelphia Point area; knotgrass, maidencane, and spatterdock thriving in October 2019; water levels have since been adjusted and plants are now submersed.

The term *maintenance control* was adopted in 1973 by aquatic plant managers in Florida when a pro-active plan to conserve native habitat was implemented. By controlling exotic/invasive plant species at the lowest feasible level, habitat critical for native wildlife can be protected, and native plants are conserved for nutrient uptake, sediment stabilization, and biodiversity. Today, 1.25 million acres of Florida's public waters are managed under the maintenance control program to prevent the colonization, establishment, and spread of exotic plants, as outlined in the F.A.C., Chapter 68F-54. Here are a few photos from two sites in Florida that are under regular and consistent management for the control of exotic plant species.

## New Hire at UF/IFAS

The UF/IFAS Pesticide Information Office is excited to announce the hire of Dr. Brett Bultemeier. Brett is one of UF's own, having completed both his masters and Ph.D. at the Center for Aquatic and Invasive Plants under the direction of Dr. Michael Netherland, and Dr. Haller, respectively. After graduation Brett spent over 7 years at Clarke as the water resource manager, helping to coordinate treatment strategies and training between sales and operations. Most recently Brett was the Southeastern Regional Sales Manager for Applied Biochemists. At the PIO, Brett will be responsible for developing new outreach materials to educate on all aspects of pesticide use and safety. He is very excited to be back in IFAS and to use his vast field experience to train and certify the next generation of pesticide applicators.

Brett Wells Bultemeier
University of Florida
Pesticide Information Office
2306 Mowry Road, Building 164
352-392-4721

# 2020 Calendar of Events

**April 22-24**
Florida Vegetation Management Association Annual Conference (Daytona Beach, FL)
https://www.myfvma.org/

**May 4-7**
University of Florida IFAS Aquatic Weed Control Short Course (Coral Springs, FL)
http://conference.ifas.ufl.edu/aw/

**June 25**
South Florida Aquatic Plant Management Society General Meeting (Holy Cross Hospital, Ft. Lauderdale, FL)
http://sfapms.org/

**July 19-22**
Aquatic Plant Management Society 60th Annual Meeting and Western Aquatic Plant Management Society Joint Meeting (Austin, TX)
http://www.apms.org/

**September 24**
South Florida Aquatic Plant Management Society General Meeting (location TBA)
http://sfapms.org/

**October 5-8**
Florida Aquatic Plant Management Society 44rd Annual Training Conference (Daytona Beach, FL)
http://www.fapms.org/

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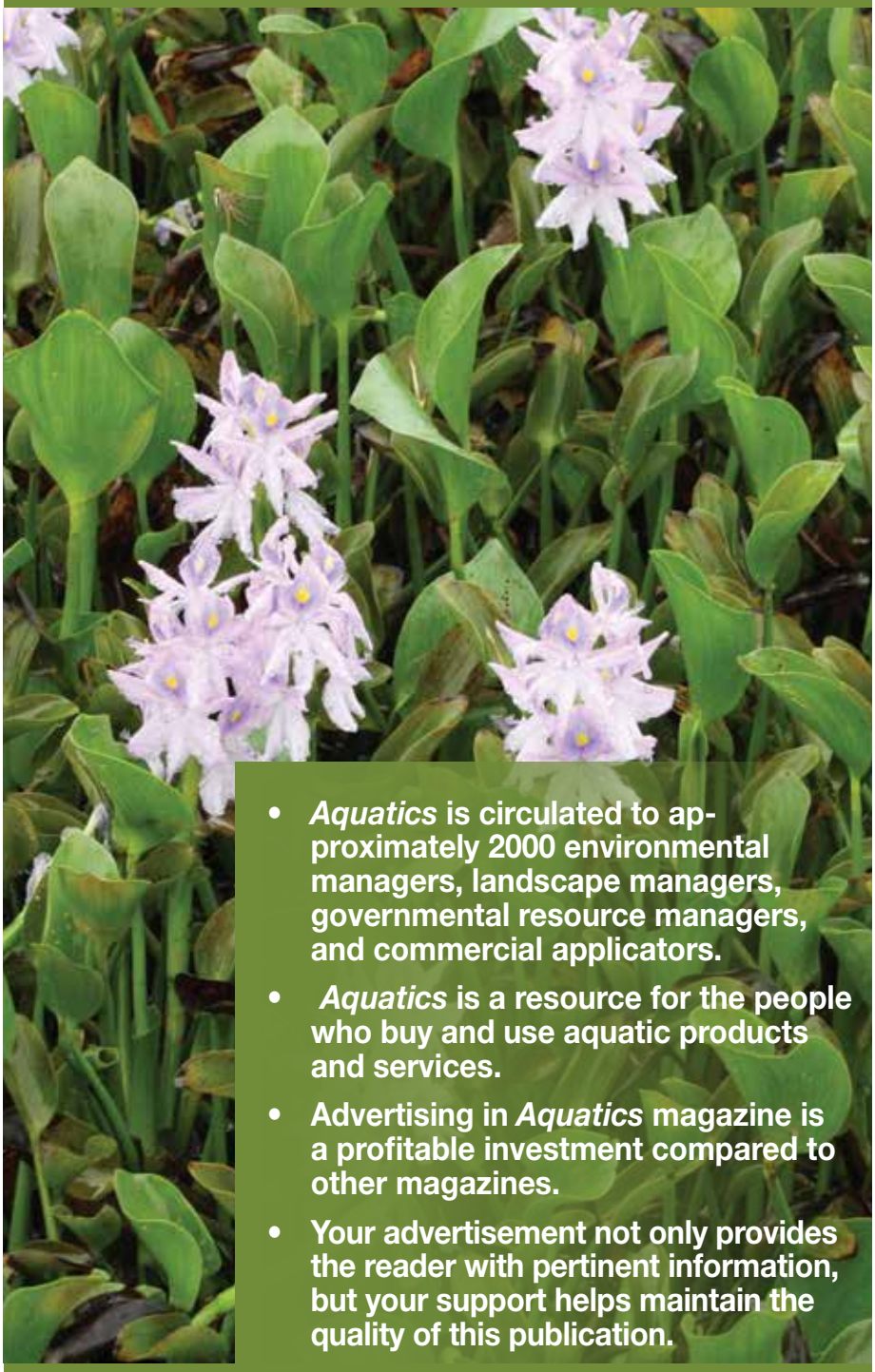

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